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Speech production accuracy and variability in Children with Down's syndrome

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ABSTRACT

The study investigated the speech accuracy and variability of 15 children with Down's syndrome, 15 children with intellectual impairment and 15 children with normal development. All participants were asked to produce 31 words from Cantonese Segmental Phonology Test (CSPT) in three spontaneous trials and three imitated trials. Results showed that significantly lower accuracy and higher variability were found in repeated productions of consonants, vowels, tones and whole-words in speech of children with Down's syndrome. Higher speech accuracy and lower speech variability upon imitation were also noted in Down's syndrome population. Using these findings, this study explored the possible etiology of speech disorder in Down's syndrome population and suggested appropriate intervention approaches targeting the underlying deficits in the speech processing chain.

INTRODUCTION

Speech accuracy is commonly considered as the major indicator of communicative competence (Kent, Miolo & Bloedel, 1994). Typically developing children begin to produce words around their one-year-old birthday and create short utterances around their two-year-old birthday. By the age of eight, they have already demonstrated a good understanding of the phonological and syntactic properties of their first language (Stoel-Gammon, 2003). However, there are groups of children who, with different reasons, fail to acquire language in the same fashion and manner as normally developing children and they are diagnosed as having speech disorders (Stoel-Gammon, 2003).

Variability is defined as repeated productions that differ, with variability caused by factors responsible for typical acquisition and use of speech. Inconsistency is speech characterized by a high variability with multiple error types which cannot be attributed to factors described in typical acquisition (Holm, Crosbie and Dodd, 2007). A cross-sectional study by Holm et al. (2007), which collected speech samples from 409 British preschool children, showed that normally developing children's speech was highly consistent. Although the younger children's speech samples were more variable than the older ones, variable productions remained below 13%. The data enabled identification of a subgroup of children whose speech errors were highly inconsistent (Mclntosh & Dood, 2008).

Among different disordered populations, low intelligibility and high inconsistency in

speech produced by children with Down's syndrome has frustrated caregivers. According to Kumin (1994), in a survey of 937 caregivers of children with Down's syndrome, more than 95% of caregivers expressed that they frequently had difficulty understanding their children. Also, persistent deficits in speech intelligibility and resistance to therapy have thwarted many clinicians (Chapman, 1995) and the speech production of some individuals with Down's syndrome, throughout their lives, remains to be unintelligible (Kumin, 1994). Over the years, researchers have developed different opinions towards the phonological performance of children with Down's syndrome.

According to Bradford & Dodd (1994) and Dodd & McCormack (1995), there are four subgroups of children with speech disorder, including articulation impairment, delayed phonological skills, consistent deviant disorder and inconsistent speech disorder.

Van Borel (1996) reported that the speech production of children with Down's syndrome frequently appeared very similar to the speech of their typically developing peers. Stoel-Gammon (1997) suggested that early phonological development of children with Down's syndrome followed the same general pattern as that of normally developing children, but proceeded in a slower manner.

Dodd (1976) was the first to suggest that Down's syndrome children made more errors and inconsistencies than children with mental retardation or normal developing children (as cited in Dodd & Thompson, 2001, p. 309). Considering the inconsistent speech errors

produced by Down's syndrome children, Dodd suggested that Down's syndrome children were having inconsistent speech disorder.

A cross-linguistic study by So and Dodd (1994), which compared the speech performance of two groups of Cantonese-speaking children, one with Down's syndrome and one with mental retardation, agreed that children with Down's syndrome were more inconsistent in the production of pairs of words than mentally retarded children. Yet, high inconsistency was also found in the mentally retarded group. The research also showed that subjects with Down's syndrome tended to make inconsistent errors and their performance in imitation were better than that in spontaneous production. A study by Ho (1997), which compared 17 Cantonese-speaking Down's syndrome children with 17 mental retarded children, agreed with So & Dodd (1994) that subjects with Down's syndrome demonstrated improved performance in imitation than in spontaneous production.

The researches describing speech performance in Down's syndrome population, particularly for Cantonese speaking children, remains relatively limited and not up-to-date. Debates on the issue of delayed versus deviant speech performance in children with Down's syndrome remain controversial. For variability measurement, no objective method has been used to statistically analyze variability scores.

Etiology

Cognitive characteristics and biological characteristics, including general intellectual

disability, specific linguistic impairment, difficulty in phonological planning, difficulty in programming motor sequences, impairment in fine motor coordination, recurrent Otitis media, middle ear anomalies, hypotonicity and macroglossia, have been hypothesized to contribute to the reduced intelligibility in children with Down's syndrome (Price & Kent, 2008). However, few of these causal factors are accepted to explain the inconsistent speech errors patterns and increased intelligibility upon imitated production in Down's syndrome population (So & Dodd, 1994).

Treatment approaches

A variety of intervention approaches have been suggested to enhance speech intelligibility in children with Down's syndrome, ranging from surgical intervention to phonological approaches to oral motor therapy (Price & Kent, 2008; Stoel-Gammon, 1997). However, inconsistency characterized by multiple error types poses difficulties on how to choose the targeting and contrasting phonemes in therapy (Forrest, Elbert & Dinnsen, 2000; Dodd & Thompson, 2001). Clinical efficacy studies by Dodd & Bradford (2000) and Crosbie, Holm & Dodd (2005) also showed that children with inconsistent errors responded less positively to therapy which targeted on phonological contrasts. Therefore, there is a need to identify effective approaches to enhance speech intelligibility and reduce variability in Down's syndrome population based on the speech errors characteristics and etiology.

Objectives

The purpose of the present study was to describe the speech performance in Cantonese-speaking children with Down's syndrome. A new scoring method by Ertmer and Goffman (2010) was used in the current study to quantify speech accuracy and variability and identify any significant difference statistically. The study aimed to confirm and to extend previous research by determining whether (1) children with Down's syndrome might have greater phonological impairment than children with mental retardation and normal development (2) children with Down's syndrome might show inconsistent speech error patterns, (3) children with Down's syndrome might show better performance upon imitation than in spontaneous production. Investigating speech performance in children with Down's syndrome could lead to identification of the possible etiology of low speech intelligibility in Down's syndrome population. It also helped to suggest the best treatment approaches for increasing speech intelligibility in Down's syndrome population.

We predicted the following in the present research:

1) It was predicted that children with Down's syndrome showed lowest speech accuracy among children with mental retardation and children with normal development. While significantly higher speech accuracy might be found in the productions of children with mental retardation and normal development.

2) It was predicted that speech of children with Down's syndrome was highly variable and

had the highest variability score among the three groups. While speech of mentally retarded children and typically developing children might show significantly lower variability in their productions.

3) It was predicted that children with Down's syndrome performed better in imitation than spontaneous production. Higher speech accuracy and lower speech variability might be identified in imitated production. While mentally retarded and typically developing children might show no difference in speech accuracy and variability in imitation and spontaneous production.

METHODOLOGY

Participant

Forty-five children with mental age between 3; 0 and 10; 0 were recruited in this study. Fifteen of the participants were diagnosed as having Down's syndrome, 15 of the participants were diagnosed as having mental retardation with unknown origin and 15 participants were typically developing children. Children with Down's syndrome and mental retardation were recruited from mild grade and mild to moderate grade special schools for the intellectually impaired in Hong Kong while typically developing children were recruited from local nurseries.

The participants with Down's syndrome, mental retardation and normal developing children were matched pairwise for mental age and chronological age. One-way ANOVAs

revealed no significant difference between the three groups in mental age, F (2, 44) = 0.013, p = .99. Dependent t-test also revealed no significant difference between the Down's syndrome group and mental retardation group in chronological age, t (14) = 0.75, p = .46. All of the participants did not have other concomitant problems (e.g. autism, ADHD, hearing-impairment or otitis media) at the time of testing. They all lived with their families and were monolingual speakers of Cantonese. The descriptive information of subject groups is summarized in Table 1:

Table 1: Descriptive information of subject groups

Groups	Number of participants	Chronological Age	Mental Age
DS	15	7;03-14;08	3;06-9;05
MR	15	6;05-14;08	3;06-9;05
ND	15	3;06-9;05	3;06-9;05

Note. DS = children with Down's syndrome; MR = children with mental retardation; ND = children with normal development.

Speech Materials

Pictures representing the words in Cantonese Segmental Phonology Test (CSPT) (So, 1992) were used in the study to elicit words production. The recording form of CSPT with the 31 targeted words is shown in Appendix 1. All Cantonese consonants, vowels and tones have at least one representation in the 31 words used in CSPT. The pictures used were color-printed on 3 by 4 inch papers for better presentation.

Procedure

Participants were assessed in a quiet room in the special schools for mental retardation or nurseries. The first five minutes were spent on rapport building with the participants. After that, the participants were asked to name the pictures. The production of 31 words was sampled in six trials. For the first three trials, the subjects were asked to spontaneously name the picture. Semantic cues were provided when the subjects failed to name the picture. The next picture card was presented when the subjects failed to name the pictures upon semantic cues. For the later three trials, the subjects were asked to imitate the words following the tester's modal. In order to prevent fatigue, breaks were provided after each trial of assessment whenever necessary and stickers and stamps were provided as reinforcement to keep the subjects' motivation and attention.

Each assessment session lasted about 30 minutes and was recorded using a Samsung YP-VX1ZB audio recorder.

Transcription and Reliability

The speech samples were recorded and online transcribed by the author using International Phonetic Alphabet (International Phonetic Alphabet [IPA], 1999). For intra-rater reliability, ten percent of the data was re-transcribed by the author two weeks after the first transcription and the reliability is 97.9%. For inter-rater reliability, ten present of the data was transcribed by the other trained transcriber and the reliability is 97.5%.

Data analysis

Segmental accuracy for imitation and spontaneous production was measured by calculating the percentage of accurate productions of consonants (initial consonants and final consonants), vowels and tones during the three trials of spontaneous and imitated productions of each word. Whole-word accuracy was measured by dividing the number of accurate consonants, vowel and tone by total number of consonants, vowel and tone within the target syllable. For instance, in the spontaneous production of /tin^{22}/(電), the client produced [ti^{22}], [tin^{22}] and [t^{h}an^{22}]. The percentage of accuracy of consonant (initial consonants and final consonants) would be 67% (4/6). The percentage of accuracy of vowel would be 67% (2/3). The percentage of accuracy of tone would be 100% (3/3). The percentage of accuracy of whole word would be 75% (9/12).

Variability measurement is a method used by Ertmer and Goffman (2010), in which a scoring approach was proposed to measure speech variability. Under this approach, regardless of speech accuracy, lower scores indicate greater consistency and lower variability while higher scores indicate lower consistency and higher variability. A variability score of 1.0 was assigned if three of the attempts are identical; a score of 2.0 was assigned if two different productions are identified in three attempts and a score of 3.0 was be assigned if three of the attempts are different. Using earlier example of /tin^{22}/(電) discussed above, the variability score of consonant would be 2.0 (four different productions are identified in six

attempts) . The variability score of vowel would be 2.0 (two different productions are identified). The variability score of tone would be 1.0 (consistent productions). The variability score of whole word would be 3.0 (three different productions are identified).

RESULTS

Comparison of Segmental and whole-word accuracy in spontaneous production

The means and standard deviations of phonological accuracy scores of spontaneous production and imitation are presented in Table 2.

Table 2: Mean Percentage of Speech Accuracy (SD)

Groups	Consonants	Vowels	Tones	Whole-words
DS	87.6 (10.4)	94.6 (6.3)	95.7 (5.5)	91.1 (7.1)
MR	97.8 (3.0)	99.9 (0.3)	100 (0.0)	98.9 (1.5)
ND	98.7 (2.2)	99.8 (0.7)	100 (0.0)	99.3 (1.1)

Note. DS = children with Down's syndrome; MR = children with mental retardation; ND = children with normal development.

A 3 × 4 (Groups × Conditions) two-way repeated-measures analysis of variance (ANOVA) analysis was conducted, with groups (Down's syndrome, Mental retardation, Normally developing) as the between-subjects factor and conditions (percentage accuracy for consonants, vowels, tones and whole-words) as the within-subjects factor. The analysis identified a statistically significant interaction between groups and conditions, F (6,126) = 4.98, $p < .05$. Results also revealed a statistically significant main effect of groups, F (2, 42) = 17.70, $p < .05$, and a statistically significant main effect of conditions, F (3, 126) = 16.95,

$p < .05$.

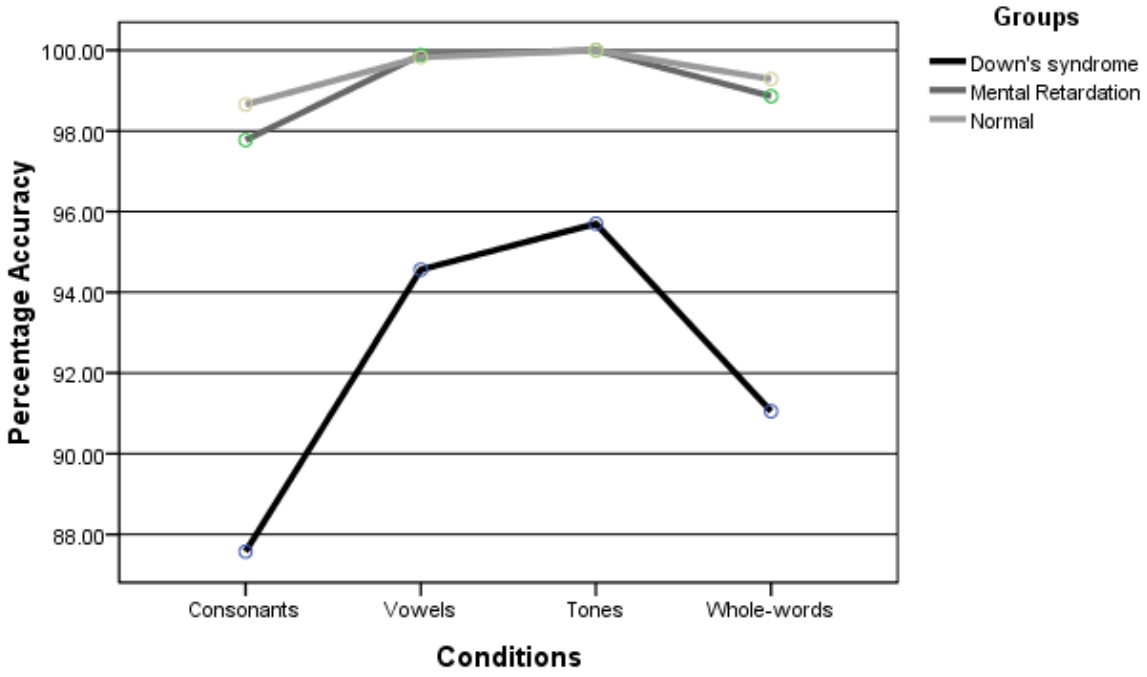

Figure 1. *Percentage accuracy of consonants, vowels, tones and whole-words by children with Down's syndrome, mental retardation and normal development.*

To further analyze the interaction effect, simple main effects of groups at each of the four conditions and the simple main effects of conditions at each of the three groups were analyzed by one-way ANOVA. The simple main effects among different conditions within each group were summarized below. Across different conditions, there was statistically significant difference in percentage accuracy among vowels, consonants, tones and whole-words in DS group, F (3, 56) = 3.57, $p < .05$, MR group, F (3, 56) = 5.85, $p < .05$, and ND group, F (3, 56) = 3.54, $p < .05$. Post-hoc Tukey testing found that percentage accuracy of consonants was significantly lower than vowels and tones in all the three groups. No

statistically significance was found among the percentage accuracy of vowels, tones and whole-word.

The simple main effects within the same condition among different group were summarized below. Among the three groups, there were significant simple main effects of consonants, F (2, 42) = 14.11, $p < .05$, vowels, F (2, 42) = 10.49, $p < .05$, tone, F (2, 42) = 9.20, $p < .05$ and whole-word, F (2, 42) = 18.16, $p < .05$. Post-hoc Tukey testing found that DS group had significantly poorer performance than MR group and ND group in the percentage accuracy of consonants, vowels, tones and whole-word. No significant difference was found in the percentage accuracy of consonants, vowels, tones and whole-word between MR group and ND group.

Comparison of segmental and whole-word variability in spontaneous production

The means and standard deviations of phonological accuracy scores of spontaneous production and imitation are presented in Table 3.

Table 3: Mean Variability Score (SD)

Groups	Consonant	Vowel	Tone	Whole-word
DS	1.14 (0.13)	1.04 (0.04)	1.04 (0.06)	1.20 (0.14)
MR	1.02 (0.04)	1.00 (0.01)	1.00 (0.00)	1.02 (0.05)
ND	1.00 (0.01)	1.00 (0.00)	1.00 (0.00)	1.00 (0.01)

Note. DS = children with Down's syndrome; MR = children with mental retardation; ND = children with normal development.

A 3 × 4 (Groups × Conditions) two-way repeated-measures analysis of variance

(ANOVA) analysis was conducted, with groups (Down's syndrome, Mental retardation, Normally developing) as the between-subjects factor and conditions (variability scores for consonants, vowels, tones and whole-words) as the within-subjects factor. The analysis identified a statistically significant interaction between groups and conditions, F (6,126) = 12.26, $p < .05$. Results also revealed a statistically significant main effect of groups, F (2, 42) = 22.67, $p < .05$, and a statistically significant main effect of conditions, F (3, 126) = 18.36, $p < .05$.

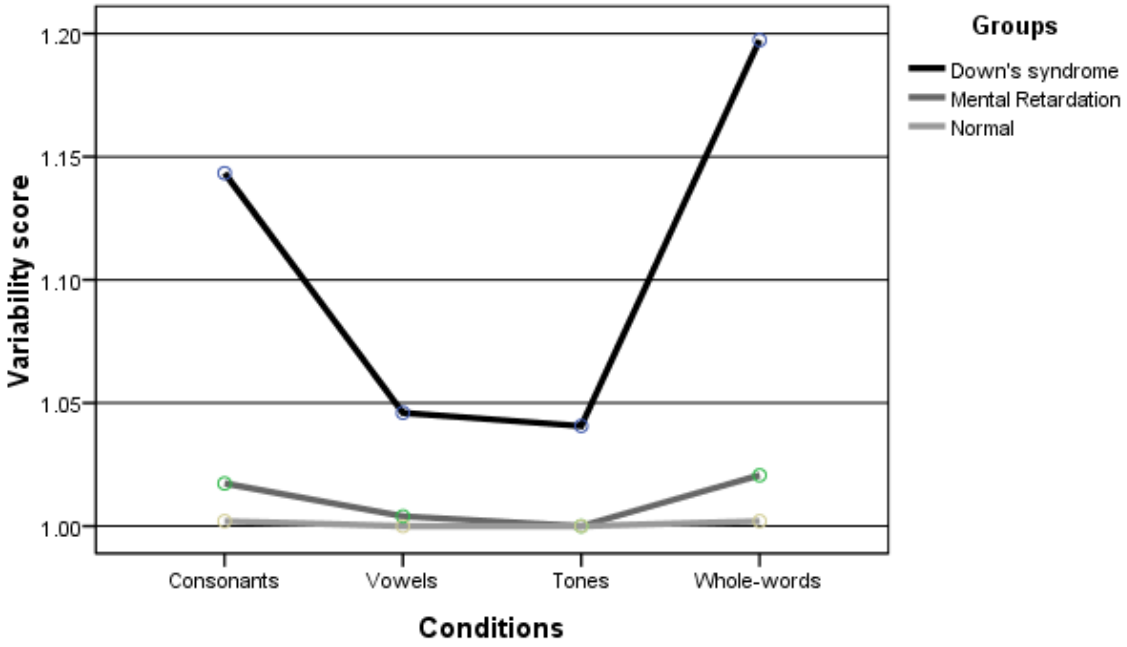

Figure 2. *Variabilty scores of consonants, vowels, tones and whole-words by children with Down's syndrome, mental retardation and normal development.*

To further analyze the interaction effect, simple main effects of groups at each of the two conditions and the simple main effects of conditions at each of the three groups were analyzed by one-way ANOVA. The simple main effects among different conditions within

each group were summarized below. Across different conditions, there was statistically significant difference in percentage accuracy among vowels, consonants, tones and whole-words in DS group, F (3, 56) = 8.37, $p < .05$. Post-hoc Tukey testing found that variability scores of consonants and whole-words was significantly higher than vowels and tones in all the three groups. No statistically significance was found between the variability scores of vowels and tones, and between the variability scores of consonants and whole-words. There was no statistically significant difference in variability scores among vowels, consonants, tones and whole-words in MR group, F (3, 56) = 1.58, $p = .20$, and ND group, F (3, 56) = 0.67, $p = .58$.

The simple main effects within the same condition among different group were discussed below. Among the three groups, there were significant simple main effects of consonants, F (2, 42) = 14.32, $p < .05$, vowels, F (2, 42) = 17.69, $p < .05$, tone, F (2, 42) = 7.91, $p < .05$ and whole-word, F (2, 42) = 23.40, $p < .05$. Post-hoc Tukey testing found that DS group had significantly higher variability score of consonants, vowels, tones and whole-word than MR group and ND group. No significant difference was found in the variability score of consonants, vowels, tones and whole-word between MR group and ND group.

Comparison of whole-word accuracy in spontaneous production and imitation

The means and standard deviations of percentage accuracy scores of spontaneous production and imitation in whole-word production are presented in Table 4.

Table 4: Mean whole-word accuracy in spontaneous production and imitation (SD)

Groups	Spontaneous Production	Imitation
DS	91.1 (7.1)	93.2 (5.8)
MR	98.9 (1.5)	99.0 (1.5)
ND	99.3 (1.1)	99.4 (1.0)

Note. DS = children with Down's syndrome; MR = children with mental retardation; ND = children with normal development.

A 3 × 2 (Groups × Tasks) two-way repeated-measures analysis of variance (ANOVA) analysis was conducted, with groups (Down's syndrome, Mental retardation, Normally developing) as the between-subjects factor and tasks (Spontaneous Production and Imitation) as the within-subjects factor. The analysis identified a statistically significant interaction between groups and tasks, F (2, 42) = 7.12, $p < .05$. Results also revealed a statistically significant main effect of groups, F (2, 42) = 17.36, $p < .05$, and a statistically significant main effect of tasks, F (1, 42) = 9.26, $p < .05$.

One-way ANOVAs were used to further analyze the simple main effects of groups and dependent-means t tests were used to analyze the simple main effects of tasks. Among the three groups, post-hoc analysis reviewed that percentage accuracy was significantly lower in DS group in both spontaneous production, F (2, 42) = 18.16, $p < .05$, and imitation, F (2, 42)

= 15.00, p < .05, than MR group and ND group. Across the two tasks, imitation was significantly better than spontaneous production in DS group, *t* (14) = -2.83, p < .05. No significant difference was identified between spontaneous whole-word production and imitation in MR group, *t* (14) = -0.91, p = .38, and ND group, *t* (14) = -1.47, p = .16.

Comparison of whole-word variability in spontaneous production and imitation

The means and standard deviations of variability scores of spontaneous production and imitation in whole-word production are presented in Table 5.

Table 5: Mean whole-word variability in spontaneous production and imitation (SD)

Groups	Spontaneous Production	Imitation
DS	1.20 (0.14)	1.16(0.12)
MR	1.02 (0.05)	1.01 (0.04)
ND	1.00 (0.01)	1.00 (0.01)

Note. DS = children with Down's syndrome; MR = children with mental retardation; ND = children with normal development.

A 3 × 2 (Groups × Tasks) two-way repeated-measures analysis of variance (ANOVA) analysis was conducted, with groups (Down's syndrome, Mental retardation, Normally developing) as the between-subjects factor and tasks (Spontaneous Production and Imitation) as the within-subjects factor. The analysis identified a statistically significant interaction between groups and tasks, *F* (2, 42) = 3.88, p < .05. Results also revealed a statistically significant main effect of groups, *F* (2, 42) = 24.26, p < .05, and a statistically significant main effect of tasks, *F* (1, 42) = 6.91, p < .05.

One-way ANOVAs were used to further analyze the simple main effects of groups and dependent-means t tests were used to analyze the simple main effects of tasks. Among the three groups, post-hoc analysis reviewed that variability score was significantly higher in DS group in both spontaneous production, F (2, 42) = 23.40, $p < .05$, and imitation, F (2, 42) = 22.11, $p < .05$, than MR group and ND group. Across the two tasks, variability score of imitation was significantly lower than variability score in spontaneous production in DS group, t (14) = 2.42, $p < .05$. No significant difference was identified between spontaneous whole-word production and imitation in MR group, t (14) = 1.05, $p = .31$ and ND group, t (14) = 1.00, $p = .33$.

DISCUSSION

This study investigated speech accuracy and variability of children with Down's syndrome as compared to a control group of children with mental retardation and a control group of children with normal development. All subjects were required to perform 6 trials of CSPT (3 upon spontaneity and 3 upon imitation). The major findings were summarized as follows:

(1) Children with Down's syndrome had greater phonological impairment as reflected in their significantly lower percentage accuracy in consonants, vowels, tones and whole-words than children with mental retardation and children with normal development.

(2) Speech production by children with Down's syndrome was highly inconsistent as

reflected in their significantly higher variability scores in consonants, vowels, tones and whole-words when compared with mental retarded children and normal developing children (3) Speech performance was better upon imitation in children with Down's syndrome as reflected in their significantly higher percentage accuracy and lower variability score in imitation than spontaneous production.

The findings of the present research were in agreement with previous researches describing the phonological performance characterized in English-speaking children and Cantonese-speaking children with Down's syndrome that lower accuracy (Roberts et al., 2005), higher inconsistency (Dodd & Thompson, 2001; So & Dodd, 1994), and better performance in imitation (So & Dodd, 1994) were identified. Hence, in spite of the differences in the English and Cantonese phonology, similar phonological patterns were obtained. This agrees with So & Dodd (1994) and Ho (1997) that the phonological deficit is an inherent part of the Syndrome, irrespective of the language examined.

Delay versus Disorder

Some researchers claimed that the children with Down's syndrome were simply having a delay in speech acquisition (Van Borel, 1996; Stoel-Gammon, 1997). Yet, the findings in this research agree with Dodd & Thompson (2001) that the speech disorder in children with Down's syndrome was not a simple language delay caused by their intellectual disabilities but a disorder of phonological acquisition. The current data suggested that children with

Down's syndrome were having inconsistent speech disorder. They tended to substituted different phonemes for one phoneme on repeated productions of the same word. Their high variability scores of consonants, vowels and tones could not be attributed to speech variability, which was found in normal speech acquisition, but speech inconsistency, which was deviant from normal development.

Possible explanations for inconsistency phonological disorder in Down's syndrome

The results from this study suggested that the difference in speech performance would not be attributed to reduced intellectual ability in children with Down's syndrome, as participants with mental retardation showed no inconsistency in their productions. Also, this study agreed with Dodd & Thompson (2001) that inconsistency in speech production could not be attributed to poorer oral motor abilities which were related to anatomical hypotonia of speech musculatures and anomalies found in Down's syndrome population since children with Down's syndrome were able to produce the accurate phonemes inconsistently upon imitation. This reflected that the inconsistent speech disorder identified in Down's syndrome population might imply underlying deficits in the speech processing chain (Dodd & Thompson, 2001).

There are currently two popular accounts to explain the etiology of inconsistent speech disorder. Kumin (2006) suggested that many children with Down's syndrome exhibited characteristics of childhood verbal apraxia and demonstrated difficulties with oral motor

planning. In the study of Kumin (2006), surveys were delivered to caregivers to identify the everyday speech characteristics of children with Down's syndrome. Survey results reflected that many children demonstrated clinical symptoms of childhood verbal apraxia including inconsistency of speech errors, reduced intelligibility with increased length of sentences and difficulty sequencing oral movements and sounds. Rupela & Manjula (2007) investigated phonotactic patterns in the production of children with Down's syndrome and the results revealed that children with Down's syndrome tended to use simpler phonotactic patterns in their productions. It agreed with Kumin (2006) that childhood apraxia of speech was possible to be presented in children with Down's syndrome (Rupela & Manjula, 2007).

However, Crosbie, Holm and Dodd (2005) suggested that children with childhood apraxia of speech were distinct from children with inconsistent speech disorder in the characteristics of speech errors and underlying deficit. Unlike children with childhood apraxia of speech, children with inconsistent speech disorder had age appropriate oral motor ability and they were better in imitation than in spontaneous production, whereas children with childhood apraxia of speech showed inability to imitate sounds (Forrest, 2003). Also, no oral motor symptoms such as poor diadochokinetic skills or grouping were identified in children with inconsistent speech disorder. Thus, children with inconsistent speech disorder had intact phonological representation and motor-speech implementation (Mclntosh & Dodd, 2008).

As the findings of the current study suggested that children with Down's syndrome showed improved performance upon imitation, this might support Bradford & Dodd (1994), So & Dodd (1994) and Bradford & Dodd (1996) that the deficit associated with inconsistent speech disorder was in the ability to assemble phonological plans for production. Neither articulatory deficits nor cognitive-linguistic deficits could explain the speech error characteristics. Dodd and McCormack (1995) suggested that children with inconsistent speech disorder might not be able to generate fully specified phonological plans for word production. Hence, as their mental representation of words was degraded or underspecified, the range of consonants produced might vary within a constrained range (Dodd & Thompson, 2001). Further research is needed to investigate the underlying deficits in the speech processing chain for children with inconsistent speech errors.

Clinical implication

Clinically, traditional therapy programs for speech disorders are based on the phonological descriptions of children's production. They mainly focused on reducing number of speech errors and expanding phonetic repertoire by approaches similar to those for children with delay phonological skills (Stoel-Gammon, 2003). However, these approaches fail to target consistency which is one of the major factors reducing speech intelligibility in children with Down's syndrome.

Crosbie, Hole & Dodd (2005) suggested that it was important for speech therapists to

differentially diagnose inconsistent from consistent phonological disorders since the two subgroups of speech disorder were caused by different deficits in the speech processing chain and responded best to different intervention approaches.

Kumin & Adams (2000) and Kumin (2006) recommended that techniques used to program and sequence movements in speech production should be targeted and trained in intervention for Down's syndrome children with childhood verbal apraxia.

The findings of this study agreed with Dodd (1995) that the major goal of therapy was to establish consistency. Dodd & Bradford (2000) and Mclntosh & Dodd (2008) suggested the use of core-vocabulary approach in intervention as it neither targeted specific sound features nor surface error patterns but targeted the underlying deficit in phonological planning. Dodd & Bradford (2000) compared three intervention approaches for children in different subgroups of speech disorder, two with inconsistent speech disorder and one with consistent deviant disorder. Results showed that children with inconsistent speech disorder benefited mostly from core vocabulary approach which focused on establishing whole-word consistency. Results also indicated that once consistency was established using core vocabulary approach, children started to benefit from phonological contrast therapy which targeted phonological awareness and encouraged reorganization of the sound system (Dodd & Bradford, 2000). Mclntosh & Dodd (2008) agreed with Dodd & Bradford (2000) that children with inconsistent speech disorder showed improvement in speech accuracy and

consistency of word production after core-vocabulary intervention.

Conclusion

In summary, children with Down's syndrome had lower speech accuracy and higher speech variability in repeated productions of consonants, vowels, tones and whole-words. Higher speech accuracy and lower speech variability was found upon imitation. These results agree with Dodd & Thompson (2001) that children with Down's syndrome are having inconsistent speech disorder.

There is increasing evidence showing that the underlying deficit of inconsistent speech disorder is associated with phonological planning and phonological assembly. However, the picture of the etiology of inconsistent speech disorder in Down's syndrome population at present is still far from clear and more investigations are required before any statements can be formulated. There is a need to identify the underlining deficit in the speech processing chain so that corresponding intervention approaches targeting the problematic process can be developed.

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Appendix A - Word list of Cantonese Segmental phonology Test

No.	**Target Words**	**IPA**
1.	眼	ŋan^{23}
2.	襪	mɐt^{2}
3.	脷	lei^{22}
4.	紐	nɐu^{35}
5.	餅	pɛŋ^{35}
6.	水	søɪ^{35}
7.	琴	k^{h}ɐm^{21}
8.	碗	wun^{35}
9.	蕉	tsiu^{55}
10.	雞	kɐi^{55}
11.	檯	t^{h}ɔi^{35}
12.	裙	k^{h}wɐn21
13.	花	fa^{55}
14.	蘋果	p^{h}ɪŋ^{21} kwɔ^{35}
15.	西瓜	sɐi^{55} kwa^{55}
16.	刀	tou^{55}

17.	貓	mau^{55}
18.	魚	jy^{35}
19.	床	ts^{h}ɔŋ^{21}
20.	巴士	pa^{55} si^{35}
21.	鴨	ap^{3}
22.	龜	kwɐi^{55}
23.	筷子	fai^{33} tsi^{35}
24.	鞋	hai^{21}
25.	電話	tin^{22} wa^{35}
26.	糖	t^{h}ɔŋ^{35}
27.	腳板	kœk^{3} pan^{35}
28.	杯	pui^{35}
29.	洗面	sɐi^{35} min^{22}
30.	粥	tsʊk^{5}
31.	耳	ji^{23}